claim for our bureau in this connection is that we sometimes recognize the obvious.

Those of us who have been responsible for the work of securing the needed appropriations are at times likely to have our judgment warped by what we think are the exigencies of the case. A member of a scientific bureau was once so concerned for the success of his bureau that he even recommended its transfer to another department so as to get under the wing of a more generous appropriation committee. The logic of the situation does not always appeal to us, and we are willing for the moment to sell our birthright for a larger appropriation. The obvious fact in this matter of the interrelations of the scientific bureaus of the government is that if the bureau chiefs do not always exhibit an appreciation of the proprieties in scientific investigation nor seem to possess much idea of perspective in the alignment of boundaries, can even the most experienced legislators be expected to make the best distribution of scientific work?

The possession by any bureau of even a skeleton organization of efficient specialists in a certain field would seem to be the practically unanswerable argument for entrusting to that bureau any new and enlarged work in that field whenever Congress deems larger appropriations advisable. That is the type of practical logic that is recognized in private business, for under public regulation of natural monopoly the public-utility company that first enters the local field is recognized and even protected by the public-service commission, as long as the service rendered is at all adequate. In the business world the day of preferment of special applicants in the granting of municipal franchises has passed, and in our government business there is no better reason for granting special privileges to overzealous bureau chiefs. I sometimes think that the bureau chief comes nearer being safe and sane in his public acts and utterances in the intervals between sessions of Congress.

In this informal comparison of the actual and the ideal in the administration of the scientific bureaus of the government, I have had ever in mind the existence of a real basis for optimism in the splendid record of the Coast and Geodetic Survey and the Geological Survey in absolutely coordinating their endeavors in the public service. And I desire simply to add that this practical cooperation has been so easily accomplished that it is only as we review these several decades of joint work and estimate the value of the reciprocal services rendered that we realize how ideal have been the relations between the two Surveys.

GEORGE OTIS SMITH
U. S. GEOLOGICAL SURVEY

ABSTRACTS OF ADDRESSES AT THE CENTENNIAL EXERCISES OF THE U. S. COAST AND GEODETIC SURVEY

APRIL 5, 1916

The Bureau of Fisheries and Its Relation to the United States Coast and Geodetic Survey: DR. HUGH M. SMITH.

Long before the Coast and Geodetic Survey and the Bureau of Fisheries were adopted by the same mother department and thus became sisters; in fact as early as 1873, when the former had already attained a robust maturity and the latter was still in swaddling clothes, there began close cooperative relations. These have continued up to the present time and have increased in intimacy and value in more recent years since the two establishments became members of the same official family. It is only fair to acknowledge that at first the cooperation was very one-sided, consisting largely of the bestowal by the Coast and Geodetic Survey of substantial favors in return for profuse thanks. From 1880, when the Bureau of Fisheries began to acquire vessels of its own, that service began to repay, in part at least, some of its obligations, and ultimately it contributed substantially to the published records of the Survey. The former has always depended on the latter for its

basic triangulation whenever a biological survey of any kind has been undertaken in a region in which the Coast Survey has operated, which of course means anywhere on the coast of the United States. On the other hand, the hydrographic and topographic results of this biological work have always been made available to the survey.

On both the Atlantic and Pacific coasts a considerable part of the offshore soundings found on the charts was determined by the steamers *Fish-Hawk* and *Albatross* in pursuance of their fishery investigations, and some of the inshore data of certain of the earlier charts came from reconnoissances by the *Albatross*. While much of the latter has been superseded by more accurate work as the Coast Survey was able to extend its operations, it served a good purpose for some years. Later there came into the command of these two vessels naval officers who had been trained in the survey, with resulting improvement in the character and accuracy of the fishery surveys, not only those under their immediate direction, but throughout the service. I can not let this opportunity pass without paying humble tribute to the distinguished labors in behalf of oceanic physics and biology performed by men like Z. L. Tanner and J. F. Moser, who, while retaining their naval status, commanded fishery vessels, and collected invaluable material for the Coast Survey.

The gathering of hydrographic and other data for use of the Coast and Geodetic Survey by the steamer *Albatross* has been particularly extensive in the Pacific Ocean and along the west coast of America.

Work Done by the United States Coast and Geodetic Survey in the Field of Terrestrial Magnetism: DR. L. A. BAUER.

From the earliest days of the establishment of the Coast Survey, magnetic observations for the prime use of the surveyor and of the mariner were considered a legitimate and useful part of its work. In the "Plan for the Reorganization of the Survey of the Coast," as adopted in 1843, explicit provision was made for the making of "All such magnetic observations as circumstances and the state of the annual appropriations may allow." Since then Congress, by annual appropriations, has continuously and increasingly recognized the importance of this feature of the work of the survey, so that in 1899 an enlarged appropriation made it possible to carry out a magnetic survey of the whole United States on a systematic basis, and with an expedition theretofore not possible.

When the first chart of the lines of equal magnetic declination, known to the surveyor and the mariner as the lines of equal variation of the compass, was issued by the Coast Survey in 1855, the number of available stations at which magnetic observations had been made amounted to about 150, and these were distributed very irregularly and covered but a limited region of our country. At the close of 1915 the number of these stations was 5,000, the stations now being distributed fairly uniformly over the United States. Besides, a vast amount of magnetic data has been compiled from other sources and the survey has also made magnetic observations at some 500 stations in our outlying possessions. The average distance apart of the places at which accurate magnetic observations have now been made in the United States is about 25 miles. Meridian lines for the use of surveyors have been established at many county seats throughout the country, magnetic data at sea have been accumulated on cruises of the Coast Survey vessels, and five magnetic observatories, where the countless fluctuations of the earth's magnetism are being continuously recorded, are at present in operation under the direction of the survey.

The contributions of the Coast and Geodetic Survey to the advancement of our knowledge in terrestrial magnetism, in fulfilment of both practical and scientific demands, have been unexcelled by any other national organization. Because of its extensive compilations of data relating to the change of the compass direction from time to time, the Coast and Geodetic Survey is able to furnish promptly information of priceless value in the adjudication of disputed land boundaries, the bearings of which were referred to the compass direction when originally laid out, 100 to 150 years or more ago.

The changes in the compass direction reach very appreciable amounts with the lapse of time. The compass even changes its direction between morning and afternoon by an amount appreciable in accurate land surveying. During a so-called magnetic storm, the compass direction may change suddenly by a degree or more. All such fluctuations are recorded at the magnetic observatories of the survey, and the information is published promptly, and made readily accessible to all interested.

The assumption frequently made by surveyors that the compass has changed its direction regularly at the rate of 3 minutes per year or 1 degree in 20 years, is not borne out by the data of the survey. At the present time, for example, in the New England states the north end of the com-

pass is moving west at the rate of about 6 minutes per annum. In Porto Rico this westerly motion is as much as 10 minutes, and along the northeastern coast of Brazil it is about 16 minutes. Thus, instead of a change of 1 degree in 20 years, there may be a change of 1 degree in 10 years or even in 5 years or less, depending entirely upon geographic location.

The Bureau of Standards and its Relation to the United States Coast and Geodetic Survey: DR. S. W. STRATTON.

The speaker sketched the history of the various standards which have been used in this country. He paid a high tribute to Mr. Hassler for creating the division of weights and measures of the survey. This division became in 1904 the present Bureau of Standards, a separate organization. He spoke of the close cooperation which has always existed between the Bureau of Standards and the Coast and Geodetic Survey.

Ocean Currents and Deep Sea Explorations of the United States Coast and Geodetic Survey: REAR ADMIRAL J. E. PILLSBURY.

After mentioning the early voyagers who came in contact with and noticed the Gulf Stream, a brief description was given of the first American investigation, that of Benjamin Franklin. On his voyages to and from Europe—and there were many—he observed the temperature of the water in the endeavor to determine the northern limit of the stream issuing from the Straits of Florida under the theory that the warmer water indicated its boundary.

It was not until 1845 under the administration of A. D. Bache that the Coast Survey began a systematic study of the Gulf Stream. From that year until 1853 many vessels were engaged in the work under the most comprehensive orders. They were to determine its limits, surface and subsurface, whether constant or variable, whether depending upon winds and how recognized, whether by temperature, soundings, vegetable or animal life, specific gravity of its water, etc.

In 1867 Professor Henry Mitchell, of the Coast Survey, began an investigation of the Gulf Stream by a new method. He sounded between Key West and Havana and observed currents to 600 fathoms by means of floating cans, or weighted cans suspended from floating cans.

The survey also used ballasted bottles to determine the course of the currents. Each one when it was put overboard contained a paper with a request to the finder to send it to some American official and to mark on it the place where it was found.

In 1883 the first attempt was made to investigate the actual flow of the Gulf Stream by a vessel at anchor, when the schooner *Drift* under Lieutenant Fremont anchored with wire rope and observed the currents between Jupiter Inlet, Florida, and Memory Rock, Bahama.

The results were of so great value that the Superintendent decided to continue the work, but the use of a sailing vessel for the purpose was considered impracticable. The time spent in reaching the anchorage and the hours required in anchoring and in getting under way by the use of hand power alone necessitated the selection of a vessel with steam for the purpose. The *Blake,* under Lieutenant Pillsbury, was the vessel chosen, and during the following five years she was engaged in Gulf Stream work each winter season and some summers. Anchorages were made in any depth required; many being in water deeper than 1,500 fathoms, and the deepest in 2,300 fathoms. The longest time at any one station was about seven days, and by the use of an instrument devised for registering the direction as well as the velocity of the currents, observations were carried on as long as the vessel remained at anchor.

As to results, it was found that the velocity of the Gulf Stream varied daily, according to the moon's transit, and monthly following its declination, and that these variations could be predicted with fair accuracy. A calculation as to its volume, deduced from many hundreds of observations in the narrowest part of the Straits of Florida, gave 90,000,000,000 tons per hour.

The United States Geological Survey and its Relation to the United States Coast and Geodetic Survey: DR. GEORGE OTIS SMITH. Printed in this issue of SCIENCE.

The United States Coast and Geodetic Survey's Part in the Development of Commerce: HON. J. HAMPTON MOORE.

Mr. Moore spoke of the relation of the Coast and Geodetic Survey to Commerce and after paying high tribute to the perseverance and loyalty of the men of the service, said that commerce itself did not fully appreciate the importance of the work. Amongst other things, he referred to the formation of shoals and the location of rocks that impede navigation.

"I am interested in the safety of life and commerce on all our coasts, but by reason of familiarity with the Atlantic coast, I may be pardoned for

calling attention to a few of its needs. Suppose some day, as many experts think probable, the Caribbean Sea should become the base of a great naval warfare. Florida undoubtedly would become a center of American activities. Her inland waterways, so far as they are fit, would be serviceable for supply and munition ships, and for small vessels of the navy. We can not count too much on these waterways now, for they have not been improved as they should have been. But what layman ever knew, or knows now, that the Coast and Geodetic Survey has 172,000 square miles of hydrographic surveying ahead of it before all sides of Florida are covered.

Our needs by way of protection against reefs and shoals around the Florida coast are far more extensive than they are in the Alaskan waters, and yet in Alaska but eight per cent. of the navigable waters have been surveyed to the satisfaction of the bureau.

The dangers of Cape Hatteras are known to every American, and the currents that abound on that treacherous coast demand the frequent inspection and oversight of the chart-makers. Just above Hatteras, along the North Carolina coast, the shore line is constantly changing, as is well known. Inlets close and open according to the whims of nature. It is an interesting historical fact that no living man is now able to locate the inlet through which passed the Sir Walter Raleigh expedition, which made the first English settlement on Roanoke Island in 1584. That the vessels of Amadis and Barlow entered Croatan Sound is well established, but the channel through which they came has long since disappeared.

The closing of inlets as far north as New York has not been of infrequent occurrence in the course of the last century, nor has the accretion or recession of land where the waves and storms have played upon it.

Near Chincoteague Inlet, Virginia, is a comparatively new harbor, known as the Assateague Anchorage. It owes its existence to a natural change in the coast line at the south end of Assateague Island, which has converted an exposed bight into a well-protected and much frequented harbor. This harbor is preferred by local shipping to some of the artificial harbors of refuge along the coast. It has an added importance because it is the only harbor between the entrances to the Chesapeake and Delaware bays, but it must be examined frequently in order that the shifting sands may be so charted as not to deceive the mariner.

Advancing along the coast to the New Jersey and Delaware shores, where shipping increases, it is observed that at the present time the Coast and Geodetic Survey stands in need of funds to survey and resurvey about 13,000 square miles off shore. There are shoals constantly forming on these shores which should be examined and charted in the interests of navigation. This is an area which is presumed to have passed the pioneer stage, but it evinces that same disposition to conform to the forces of nature that prevail in less frequented waters.

More remarkable than this, however, is the situation with respect to the waters approaching the great metropolis of New York. The Rivers and Harbors bill, now pending in the House of Representatives, carries an appropriation of $700,000 to extend and deepen the channel from the sea to the Brooklyn Navy Yard, a very important work that should have been completed long ago. The reason for this appropriation is that there are obstructions in the channel, possibly of rock foundation, which make navigation perilous for the dreadnaughts of the navy. When vessels of 12 feet draft were sailing into New York harbor it made no difference about this channel, but the increase in the size and draft of vessels has made a difference, and the lead and the drag must be invoked again.

There are rocks in the East River, as every one knows. Some of them are of the pinnacle type, and strange as it may seem have only recently been located. As late as 1915 the wire drag was used by the Coast and Geodetic Survey in the East River, locating certain dangerous shoals which are a menace to navigation, and which in the event of war would seriously handicap our battleships. If commercial New York, exposed as it is to the guns of a hostile fleet, is just beginning to make discoveries of new formations and obstructions in its waterways, it is high time that the people elsewhere along our coast lines should wake up to the importance of increasing and developing the Coast and Geodetic service.

I have not time to further discuss the work along the Atlantic coast except to say that the Maine waters abound in rocks and shoals. The wire drag service is badly needed there, as it is all along the New England coast. The report of a recent survey in the vicinity of the Rockland Naval Trial Course discovered no less than four shoals, on any one of which a battleship might have been seriously damaged. It is noteworthy also that in a survey of the approaches to Narragansett Bay, one of our most beautiful sheets of water, evidences of hidden formations were discovered. As

late as 1914 the wire drag party found no less than 50 shoals at the entrance to Buzzard Bay, from which vessels now pick their way into the newly constructed Cape Cod Canal.

The United States Corps of Engineers and its Relation to the United States Coast and Geodetic Survey: BRIGADIER GENERAL W. M. BLACK.

The association in work of the corps of engineers and the United States Coast and Geodetic Survey began with the organization of the Coast and Geodetic Survey.

The Corps of Engineers was organized as a separate body in 1802 and of it the U. S. Military Academy formed a part. The first superintendent of the Coast and Geodetic Survey, Ferdinand R. Hassler, was appointed from the corps of instructors of the academy, having served there as acting professor of mathematics from 1807 until 1810.

When the necessity for the better mapping of our coasts was impressed upon President Jefferson he selected Hassler to take charge, though it was not until 1816 that the work of the survey was actually begun. About a year later the work was discontinued, though the survey of the coasts was carried on thereafter by officers of the engineers and of the Navy until the bureau resumed its operations under Hassler in 1832.

Among the engineer officers on duty on survey work prior to 1832 was John J. Abert, who as major and lieutenant colonel, was engaged in many surveys of the coast from 1816 to 1827.

For several years beginning in 1818 the international boundary surveys required under the Treaty of Ghent were carried on along the northern boundaries of New York, Vermont, New Hampshire and Maine. Second Lieutenant Delafield, Captain Partridge and Professor Ellicott of the corps of engineers and Professor Hassler of the Coast Survey were engaged in the work.

When in 1843 it was deemed necessary to reorganize the Coast Survey the corps of engineers again lent its aid. Alexander Dallas Bache, a graduate of the Military Academy of 1825, and during his period of service in the army an officer of the corps of engineers, was appointed superintendent and remained as the head of the survey until his death in 1867.

In announcing his death the Secretary of the Treasury paid tribute to the value of his services in maintaining the high scientific character of the survey.

From 1843 through a period of many years, officers of both the Army and Navy served by detail with the Coast Survey Bureau.

The accurate method of observing latitude with the zenith telescope was the invention of Captain Andrew Talcott of the corps of engineers.

This record shows how directly the corps of engineers has been interested in the work of the Coast and Geodetic Survey.

During the past half century the two services have had few opportunities to associate in the same work, but the association of the two organizations does not end with this. Their work is mutually helpful.

When a harbor is to be improved the first recourse of the army engineer is to the charts of the Coast and Geodetic Survey, by means of which the changes which have occurred are studied and on these studies plans for improvement are afterwards formulated.

The triangulation points established by the Coast and Geodetic Survey are used when available as a basis for the work of the engineers.

Free interchange of information is made between the two organizations and the work of one supplements that of the other.

In a recent examination by the United States engineers of East River, New York, it became necessary to study the tides and tidal currents to determine the probable effect of certain proposed works. A careful study made in former years by Professor Henry Mitchell, of the Coast and Geodetic Survey, furnished much of the information required and checked closely with later observations by the engineers.

In considering plans for the improvement by the United States engineers of the Hudson River, a study of the tides and currents is of the utmost importance. Scientific research of this kind falls within the duties of both the corps of engineers and the Coast and Geodetic Survey.

To the unthinking it might appear that once the coasts had been charted the need of further surveys would cease. Such is not the case. The sea is both a builder and destroyer of shores and her labors are unceasing. Maps require constant and periodic revision.

In yet another way the work of the Coast and Geodetic Survey is useful to and is utilized by the corps of engineers and that is in the preparation of projects for national defense. For this purpose the charts of the Coast and Geodetic Survey are at once available.

The work of the Coast and Geodetic Survey and

that of the United States engineers touch at many points, but their respective spheres of duty are well defined and separate.

The great work done by the Coast and Geodetic Survey in its hundred years of existence and the traditions of faithful labor well performed will always be an inspiration for further effort.

The Lighthouse Service and its Relation to the United States Coast and Geodetic Survey: GEORGE R. PUTNAM.

All progressive maritime countries have recognized their obligation to survey their coasts and to light and mark them. When a country builds a lighthouse or publishes a chart of its coast, it aids the whole family of maritime nations, and such works show an international public spirit.

At the very beginning of our national government an act was passed, approved August 7, 1789, providing for maintaining the lighthouses. There were then but eight lighthouses in operation within the United States. From that small beginning has grown the present Lighthouse Service of this country, the most extensive lighthouse system under a single organization in the world. It maintains 14,544 aids to navigation; it employs 5,792 persons and uses 113 vessels in its work.

Maintaining lights, fog signals, buoys and beacons to guide vessels has required, in order to reach the highest effectiveness, the utilization of available apparatus and the development of new apparatus of a high order. There has been a continuous and a steady advance from the time of the first lighthouse in this country.

An accurate and thorough hydrographic survey of the coast is a necessary preliminary to the intelligent location of lighthouses and buoys and beacons; in fact, without an accurate chart it is always possible that a buoy or beacon may be stationed so as to lead a vessel directly on to some hidden and unknown danger.

The lighthouse work and the coast survey work have an important object in common; the purpose of both is to protect mariners and keep them out of danger, to give the shipmaster all possible help to steer a safe course. One gives him the map showing where the water is safe for his vessel, the other gives him the light, fog-horn and buoy to guide him over this course.

These services cooperate in many ways. The Coast Survey has made special surveys needed in connection with selecting the location for lighthouses, and has determined accurately their locations. The Lighthouse Service promptly marks new dangers located in the course of surveys, such as the wire drag work, and changes the position of buoys and other aids as is shown to be necessary by revised hydrography; it aids the Coast Survey with any information obtained by its vessels. A great amount of work is required in locating the aids correctly on the charts, and in keeping this information correct, and in this work there must be close cooperation between the services. On a single chart, that of New York harbor, there are shown 299 aids to navigation.

As both nature and the works of man are constantly changing the coast line, channels and harbors, and as the course and needs of commerce also are ever varying, it is evident that both the charts and the beacons for the aid of mariners must ever be corrected and modified; therefore the cooperation in these two important works must always be continued as in the past.

Hydrography and Charts, with Special Reference to the Work of the United States Coast and Geodetic Survey: GEORGE WASHINGTON LITTLEHALES.

A century ago, the states and the people, through their senators and representatives in Congress, authorized the President of the United States "to cause a survey to be taken of the coasts of the United States in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes or headlands, together with such other matter as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid."

Congress has shown the strength of intention underlying this enactment by making continuous annual appropriations through the one hundred intervening years and by authorizing as an aid to the prosecution of so important a public task large drafts from the army in earlier years and yet larger ones from the navy as long as they could be spared from the exacting needs of the battle fleet.

How was this justifiable, and how justifiable was it? The results served the life of the nation. No cargo is ever exported or brought home without invoking the protection of this survey; no ship ever enters or leaves our ports without receiving its aid.

In proceeding oceanward from the borders of the continent, along which the triangulation or

mensurational framework of the Coast Survey has been conducted and the topography delineated, the land dips gradually under the sea. It is the province of marine hydrography, by means of measurements of the depth of sea located in position with reference to the triangulation on shore, to discover and to chart the features of this submerged bordering land, thereby indicating the hidden dangers to be avoided by mariners and the channels where safety is to be sought in the guidance of shipping. The mission of the hydrographer has thus been that of a pathfinder to lead the way to our ports and harbors, not only at home, but also in the distant countries over which the jurisdiction of the United States extends; to tell the seafarer of the favoring tide, and by how much his compass declines from the true meridian; and to warn him where his safety is beset.

It must be with no small degree of pride that men should trace their professional lineage to a calling which has prepaid the premium of a policy of insurance upon the seaborne commerce of the United States and made the coast of the United States its best known geographical feature—a calling reaching so far back into the history of our country, so enriched with the heroisms of the sea and with the names of illustrious defenders of the nation, and so unexcelled for the aggregate of its influences in promoting the security of shipping and safeguarding the lives of seamen.

The Contribution of the United States Coast and Geodetic Survey to Geodesy: WILLIAM HENRY BURGER.

To be printed in SCIENCE.

The Civil War Record of the United States Coast and Geodetic Survey, and what the Survey is Doing towards Preparedness: REAR-ADMIRAL RICHARD WAINWRIGHT.

My acquaintance with the U. S. Coast and Geodetic Survey for over sixty years is my warrant for attempting to give the record of the field force of the survey during the Civil War. During my boyhood days I have listened to many talks about the deeds of the field force of the survey and have met many of the assistants who served in the army and navy during the Civil War. Their names would sound familiarly to the old cave-dwellers of this city. They were early volunteers of their services to the country, and their assistance was eagerly sought by generals in the field and admirals afloat. The officers of the survey were in frequent consultation with officers of the army and the navy in regard to operations along the coast, and in nearly all naval and military movements they aided by making reconnaissances and soundings, placing buoys and piloting in interior waters. The field force of the Coast Survey gave valuable military service to their country during the Civil War and afterward they returned to their regular duties, without any of the rewards of rank or pay or pension, for themselves or their families, so freely distributed at this time for military services; but they had the satisfaction that is the reward of all earnest workers of knowing that:

"Duty done,
Is Honor won."

Prior to the Civil War, and again some time after its close, naval officers were detailed to duty with the survey. They had the opportunity of learning to command and to exercise their own initiative. They had to learn to conquer difficulties and to make things do, for in no other government service is more required and smaller means provided for its accomplishment than in the Coast Survey. I am glad to see that the present superintendent is gradually forcing the Coast and Geodetic Survey from its dignified scientific obscurity into the light of the public eye. Congress will not appropriate liberally unless the public is interested.

The constant work of keeping our numerous harbors and channels correctly charted, with the aids to navigation located and the tides computed, is necessary for the commerce of peace, as well as in preparation for war; and there are points where a close survey is of value to the navy, although of little use to commerce.

In time of war the field force of the Coast Survey will be needed as it was during the Civil War. The army and navy are both very short of officers and there is little likelihood of its being otherwise for many years. A trained topographer would always be of value on the staff of a general. In modern war, with long-range guns, the general must visualize his work by close reference to the map and a topographer from the Coast Survey would find little training necessary to keep the new features and movements of the troops plotted ready for the commanding general.

In the navy a skilled hydrographer would prove a most valuable addition to the staff of an admiral. His power of quickly locating his position on a chart would be of assistance in bombardments, blockading, mining and counter-mining.

On the practical side the work of the survey has been well done and with economy. The Coast Survey charts stand at the head of all others for accuracy, execution and general usefulness. The

field force of the Coast Survey has always given loyal service to the country. If war should come they and their distinguished superintendent will be prompt to offer their services. They will be again ready. May they then find the nation more grateful than did those who were detailed from the survey during the Civil War.

The International Work of the United States Coast and Geodetic Survey: Dr. Otto Hilgard Tittmann.

Speaking of the international work of the Coast and Geodetic Survey done in direct cooperation with other countries, Dr. Tittmann said that it may justly give satisfaction to the members of the survey that the results of its work are nearly all international in their scope.

The hydrographic and tidal surveys are obviously for the benefit of all mankind because they safeguard the commercial intercourse of nations. Its geodetic work contributes to the knowledge of the earth's dimensions and constitution. The world's knowledge of terrestrial magnetism would be incomplete without the record of the observation of magnetic phenomena as they occur in the vast territory inhabited by us and so with those relating to the tides. Thus in the prosecution of its tasks, the survey adds to our knowledge of the planet which we inhabit and thereby furthers the ultimate aim of all civilization, the intellectual development of mankind.

He then referred to Senator Sumner's speech delivered immediately after the acquisition of Alaska in which Sumner spoke of the north and south boundary of the territory just acquired as extending to the frozen ocean or the "North Pole if you please." Mr. Tittmann evidently believes that the Senator intended to lay the foundation for a claim to any land which might lie between Alaska and the North Pole. He pointed out that Admiral Peary visited the North Pole end of the line, and that during the famous journey he was formally attached to the Coast and Geodetic Survey for the purpose of observing Arctic tides.

After briefly reviewing the delimitation of the Alaska boundary, extending over a length of about 1,800 miles, by the survey, Dr. Tittmann described the part taken by the survey in the delimitation and remonumenting of our northern and also of the Mexican boundary, undertakings which he considered the most striking of the survey's international accomplishments.

He then spoke of the relation of the Coast Survey to the International Geodetic Association and its supervision of two small astronomical observatories for observing the variations of latitude, maintained in this country by the association. He also described the survey's share in the scientific work leading to the establishment of the International Bureau of Weights and Measures, pointing out that the directorship of this important bureau was offered to the American delegate, Mr. Hilgard, of the Coast and Geodetic Survey, but was declined by him.

International scientific expeditions made by the survey, including transit of Venus expeditions, and those for observing solar eclipses, were rapidly passed in review by the speaker, who, in concluding, expressed the hope that the next centennial celebration of the Coast and Geodetic Survey might afford as satisfactory a retrospect as the present.

Oceanic Tides with Special Reference to the Work of the United States Coast and Geodetic Survey: Dr. Charles Lane Poor.

The mathematical theory of the tides begins by assuming a solid earth surrounded by a shallow, frictionless ocean. In such an ocean the attraction of the moon would cause waves to travel around the earth from east to west. For many years the complete mathematical solution of this simple problem taxed the ability of the ablest scientists, and when finally solved the solution did not materially advance the theories and explanations of the actual tides in the oceans as they exist on the earth.

To pass from this ideal world to actuality; from a simple all-pervading ocean of uniform depth, to oceans separated by continents, and varying in depth, defies the skill of the mathematician. Yet Newton, Laplace and a succession of brilliant mathematicians have all tried to do this; to pass from the simple to the complex. They consider the tides as a world phenomenon—as an ideally simple wave, modified, broken up, and delayed by the continental barriers; by the varying depths of the oceans. Sir George Darwin considers the great earth tides as formed in the broad, deep waters of the southern Pacific. From here the tidal wave spreads east and west, around Cape Horn and past Cape of Good Hope, and sweeps through the Atlantic at a rate depending solely upon the depth of the water.

This simple world idea of the tides was evolved and elaborated from observations of the tides of Europe. In the days of Laplace there was little knowledge of the tides in other parts of the world, and it was naturally thought that the European tides were fairly representative. The dy-

namical, or world wave theory, fitted and explained the simple tides, and thus became the basis of all tidal work and theories. Later the tides in the Pacific and Indian oceans were studied and were found to differ greatly from those of Europe, in fact, the tides of the North Atlantic are exceptional in their simplicity. Yet as each new complication was found, it was explained away, as a modification of the general grand wave, due to some local condition. The theory that the tides are a world phenomenon has the support of the world's greatest mathematicians and all the prestige their names can lend.

Certain investigation of the Coast and Geodetic Survey would indicate that this theory may not be the correct explanation of the oceanic tides. During the century of its existence this body of skillful observers and able investigators has collected and discussed an enormous amount of tidal data in both the Atlantic and the Pacific oceans. As these observations were collected and brought together, discrepancies were found; the tides of one port could not be fitted into and made to harmonize with the tides of another place. A few such discrepancies could be explained as modifications of the general tidal wave, but as observations were increased in number, discrepancies multiplied, and to fit all conditions, the general tidal wave would have to writhe and squirm, and change its form and character from place to place until it lost all semblance of a single uniform progressive wave. Gradually there has been evolved the feeling that the tides are not a world phenomenon, but are strictly local in character and in being; that the tides of the Atlantic Ocean are due to the oscillations in the waters of the Atlantic, independent of what has or may happen in the waters of the Pacific.

This idea of the tides as purely local phenomena, as opposed to the theory of a grand earth-wide wave, has been elaborated and developed by the Coast and Geodetic Survey into a thoroughly consistent theory. And this explanation of the tides stands out as the great scientific contribution of the Coast and Geodetic Survey to the theories of oceanic tides.

The Contribution of the United States Coast and Geodetic Survey to Physical Geography: DR. DOUGLAS WILSON JOHNSON.

Every division of physical geography is indebted to the U. S. Coast and Geodetic Survey for the invaluable contributions which it has made during the past hundred years of its existence.

Considering the general earth relations, we owe to the services of this organization much of our knowledge concerning the size and form of the globe. Among the Coast and Geodetic Survey's contributions along this line are its longitude determinations, international cooperative work in the determination of the variation of latitude, and the gravity and azimuth observations made in connection with extensive triangulation work. Terrestrial magnetism has received a special study along this line, and has added largely to our stock of information on this important phenomenon of the earth.

The physical hydrography of the ocean has been enriched by the detailed study of the form and composition of the bottom through the regular hydrographic operations of the survey and special oceanographic cruises which they have made. Our knowledge of the Gulf Stream and other currents of the ocean and its tributaries comes largely from the researches of the survey. Its work along tidal lines and regarding tidal currents has been truly monumental, and among its many important contributions along this line may be mentioned the exposition of the equilibrium theory of tides, and its development.

In the study of land forms, the detailed charts of coastal features revised by frequent resurveys gives a complete record of the changes in coastal topography, and by throwing considerable light on the laws of wave and current action have proven to be of incalculable value.

Even the physical geography of the atmosphere is indebted to the survey, for Ferrel's meteorological researches and other studies of the winds and related phenomena are among the important contributions of the survey along those lines.

At the banquet, on April 6, in addition to the address of the president of the United States, printed above, the following addresses were made:

The Minister of Switzerland said in part:

It may surprise some of you that the only foreigner who has the privilege to say a few words on this festive occasion is the Swiss minister. Needless to state that there is no foundation whatsoever for the facetious suggestion that profound political reasons governed the choice of the representative of the only country which has no coasts, no harbors and no navy, to assist in this Jubilee Celebration of the United States Coast Survey.

I owe my presence here to the circumstance which is alike honorable and agreeable to me, that the first superintendent of the Coast Survey, which now has grown so great and celebrated, was the Swiss engineer Ferdinand Rudolph Hassler.

At all times in the history of the United States some of my countrymen may be found, who assisted in the development of this country and who have made a place for themselves in the hearts of grateful Americans.

The activities of Professor Hassler, as founder of two of your great national enterprises, that is, of the Coast Survey and the Bureau of Standards, took place in the first half of the nineteenth century. A retrospect shows us, that during those fifty years my countryman had as contemporaries several distinguished Swiss, who emigrated to this country at about the same time. First among them, it gives me particular pleasure to mention Hassler's friend, Albert Gallatin, of Geneva.

Actuated by the same spirit as Lafayette, Gallatin at the age of eighteen crossed the ocean in order to fight for American independence. Later on he achieved the highest honors open to a Swiss in this country. He was not only the first foreign-born Senator of the United States, but for twelve years he served with acknowledged ability and success as Secretary of the Treasury under Jefferson and Madison. He went to England with John Quincy Adams as a peace commissioner and remained abroad until 1823 as Minister to Paris. After his return he declined the offer of the Democratic party to become a candidate for the Vice-presidency, because he wished to devote all his time to his scientific studies of finance, history and ethnology.

Not less well known to you, gentlemen, is the name of the Swiss naturalist, Louis Jean Rudolph Agassiz, of Motier, who during the twenty-seven years of his incumbency made famous the chair of zoology at Harvard. His son, Alexander Agassiz, who was born at Neuchatel in 1833, and who labored in the same field of research at Harvard as his father, was at one time an aid in the Coast Survey, with which he remained closely associated, as shown in his book "Three Cruises of the *Blake*." A very special reason for mentioning his name is that he was so highly esteemed by President Cleveland that the latter offered him the superintendency of the survey, but Agassiz preferred to continue his favorite researches.

The Secretary of the Navy, the Hon. Josephus Daniels, spoke of the cooperation between the Coast and Geodetic Survey and the navy and called particular attention to the fact that for a number of years naval officers were detailed for duty in the survey, where they had charge of the vessels engaged upon the hydrographic work. When the Spanish war began the naval officers returned to the regular naval duties on the fleets. Since that time all of the work of the Coast and Geodetic Survey has been done by civilians.

The Secretary of Commerce, the Hon. William C. Redfield, said in part:

The record of service that we close to-night is one of which any group of men may well be proud. The fine traditions of this service that survive in your hearts I know are dear to you. I know a little of what they have meant to you of personal sacrifice and of struggle under adverse conditions. I know what you have done in the lonely places of the world, unseen and unwatched, untold, with none to advertise. I want it known that we here know and appreciate and honor the men who carry the burden and heat of the day.

The work of surveying and engineering is not spectacular. It is not comfortable to climb a mountain peak with a pack of instruments upon your back. There is nothing that gets readily glorified in being a victim to mosquitoes in Alaska.

There are fine traditions in this survey and there are curious ones. I think it is not generally known that the artist Whistler was a draftsman in the Coast Survey. He is said by his fellow draftsman, who was a grandson of Francis Scott Key, the author of the "Star Spangled Banner," to have made more sketches than he did drawings.

I want to speak to you very briefly of the present and the future of the Coast Survey; what it is, what it has with which to work, what its task is, what it hopes to do.

The work is splendid in its sweep, from the Sulu Sea just north of Borneo to the cold waters of Alaska in the Pacific, and from the tropical waters around Florida to the Canadian coast in the Atlantic, and on all the continental area of the United States between, and all along the backward limits of Alaska.

Dr. T. C. Mendenhall, former superintendent of the Coast and Geodetic Survey, took as his theme the salient features of the careers of the various superintendents of the survey, starting with Hassler. He sketched the development and progress of the survey during its one hundred years of existence and expressed the hope that its work during the next century might compare in character with that of the first.